USING ALGAE TO ASSESS ENVIRONMENTAL CONDITIONS IN WETLANDS

R. Jan Stevenson[1], Paul V. McCormick[2], and Russ Frydenborg[3]

[1]Department of Zoology, Michigan State University, East Lansing, MI 48824-1115

[2] The Nature Conservancy, 303 Pine St, Suite 101, Klamath Falls, OR 97601

[3] Florida Department of Environmental Protection, 2600 Blairstone Rd., Mailstop 6511, Talahassee, FL 32399-2400

Why Use Algae in Ecological Assessment?

- Intrinsic Values
- Source of Problems
- Sensitive, Precise & Informative Indicators
- Easy, cost-effective

Why Use Algae in Ecological Assessment?

- Intrinsic Values
  - Biodiversity
  - Base of Food Web
  - Nutrient Cycling
  - Substrate Stabilization
  - Habitat for other Organisms
- Source of Problems
  - Oxygen Depletion
  - Habitat Alteration
  - Drinking Water
    - Taste & Odor
  - Recreational Aesthetics
    - Turbidity & Smelly
  - Toxicity

Why Use Algae in Ecological Assessment?

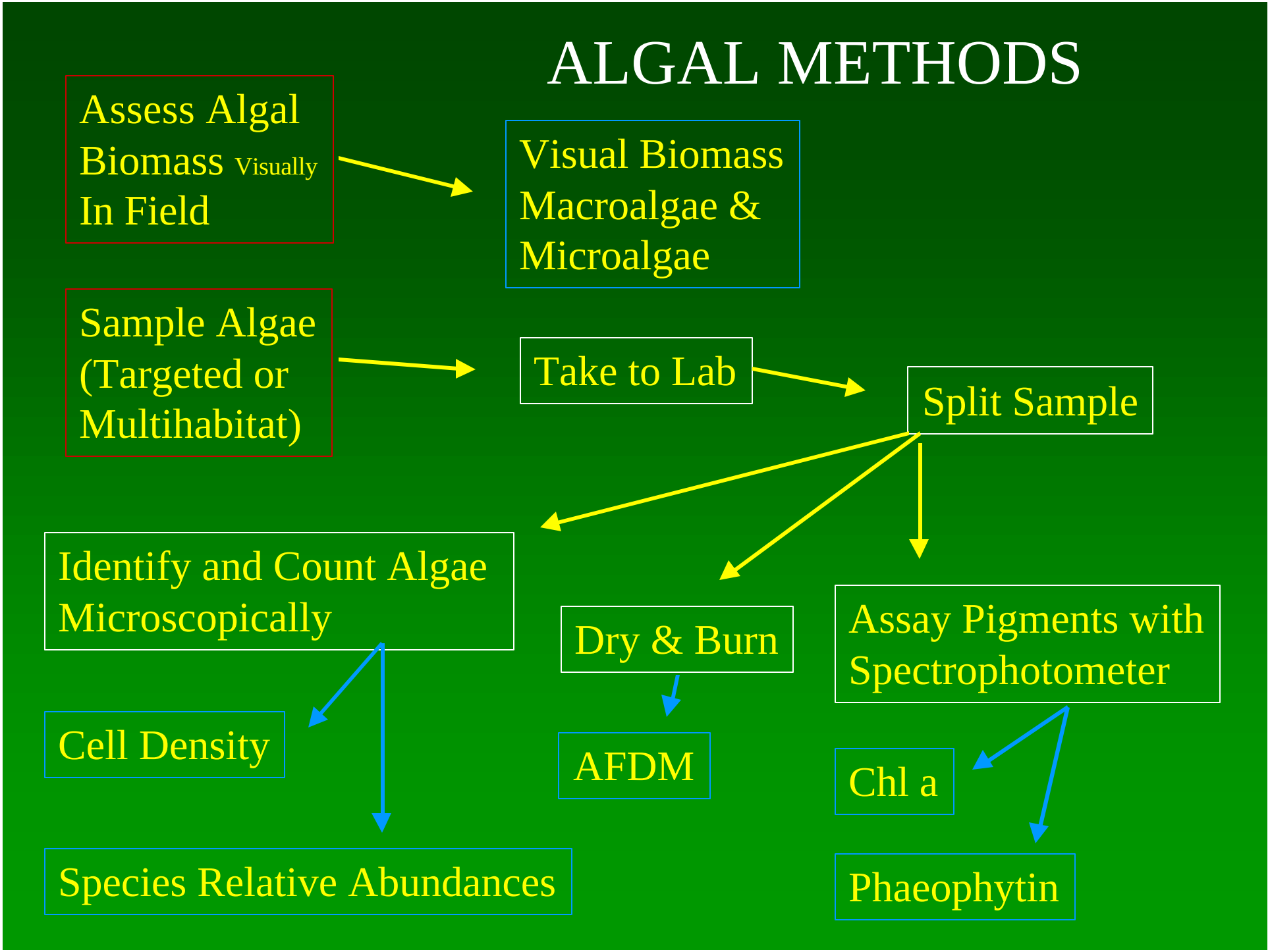
- Good Indicators
  - Diverse & Sensitive Spp.
  - Species Identifiable
  - Low Cost of Sampling and Analyzing
  - Reproduce and Respond Rapidly
- Good Indicators
  - Broad Index Period
  - Found in All Aquatic Habitats
  - Diatoms Record Habitat History in Sediment Record

COMMONLY MEASURED ALGAL ATTRIBUTES

- Assemblage Structure
  - Biomass
    - chl a, AFDM
    - cell density
  - Species Composition
  - Chemical Composition
    - P, N, C
    - phaeophytin

- Assemblage Function
  - Photosynthesis
  - Respiration
  - Phosphatase Activity

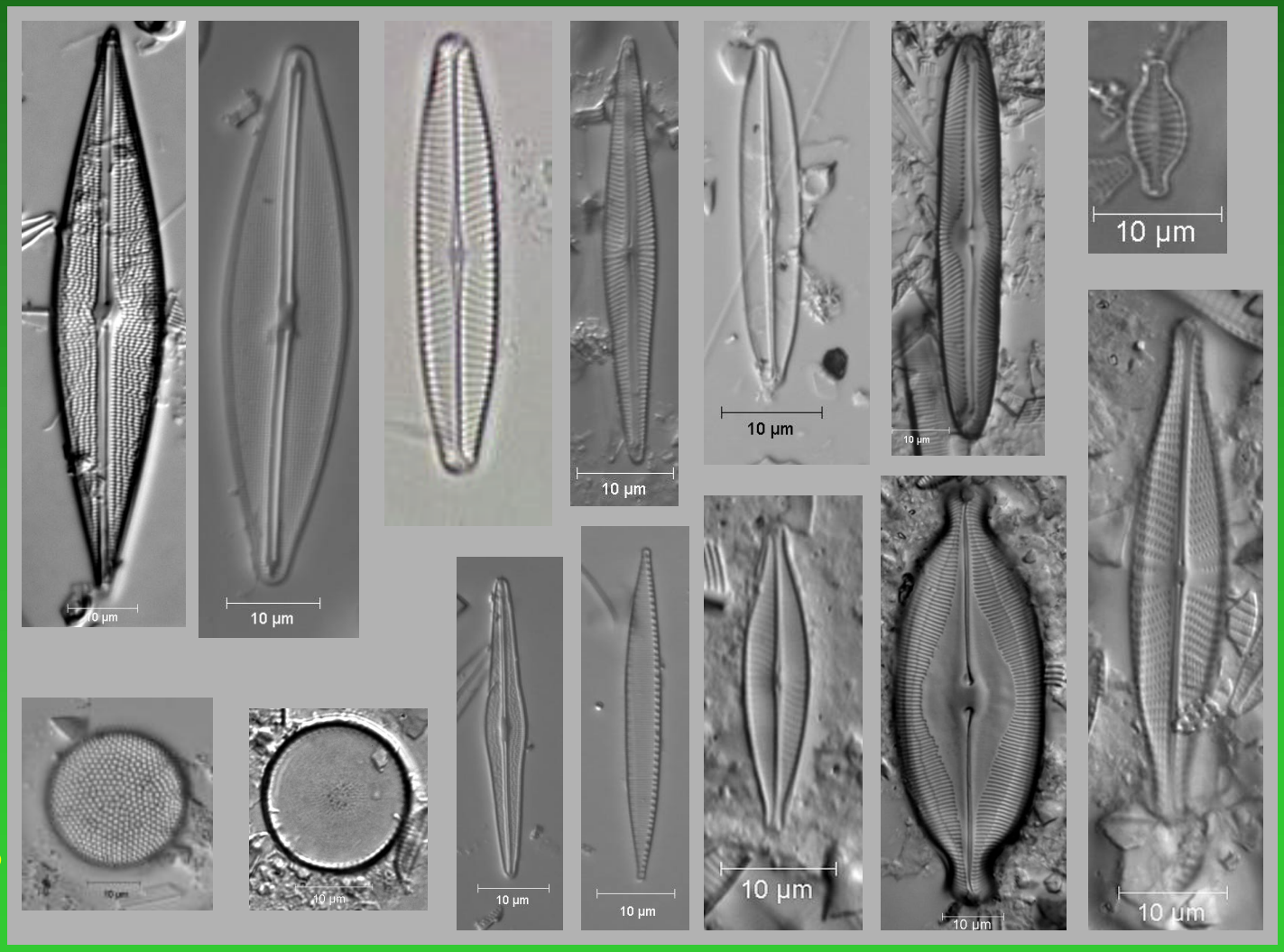
ALGAL METHODS



Identification is relatively easy

If you knew their names, you could distinguish easily among these taxa.

You can find their names with photographs and descriptions in multivolume sets of books.



Indicators
Based on Species Composition

- Response Indicators
  - % Pollution Sensitive Spp.
  - Similarity to Reference
  - % Diatoms
  - % Abnormal Diatoms
  - Diversity
    - Number Native Taxa
    - Number of Non-Native Taxa
    - (Spp. Richness, Evenness)
- Stressor Indicators
  - % Eutrophic Spp.
  - % Acid Tolerant Spp.
  - % Salt Tolerant Spp.
  - % Motile Genera
  - Inferred pH
  - Inferred TP
  - Inferred conductivity

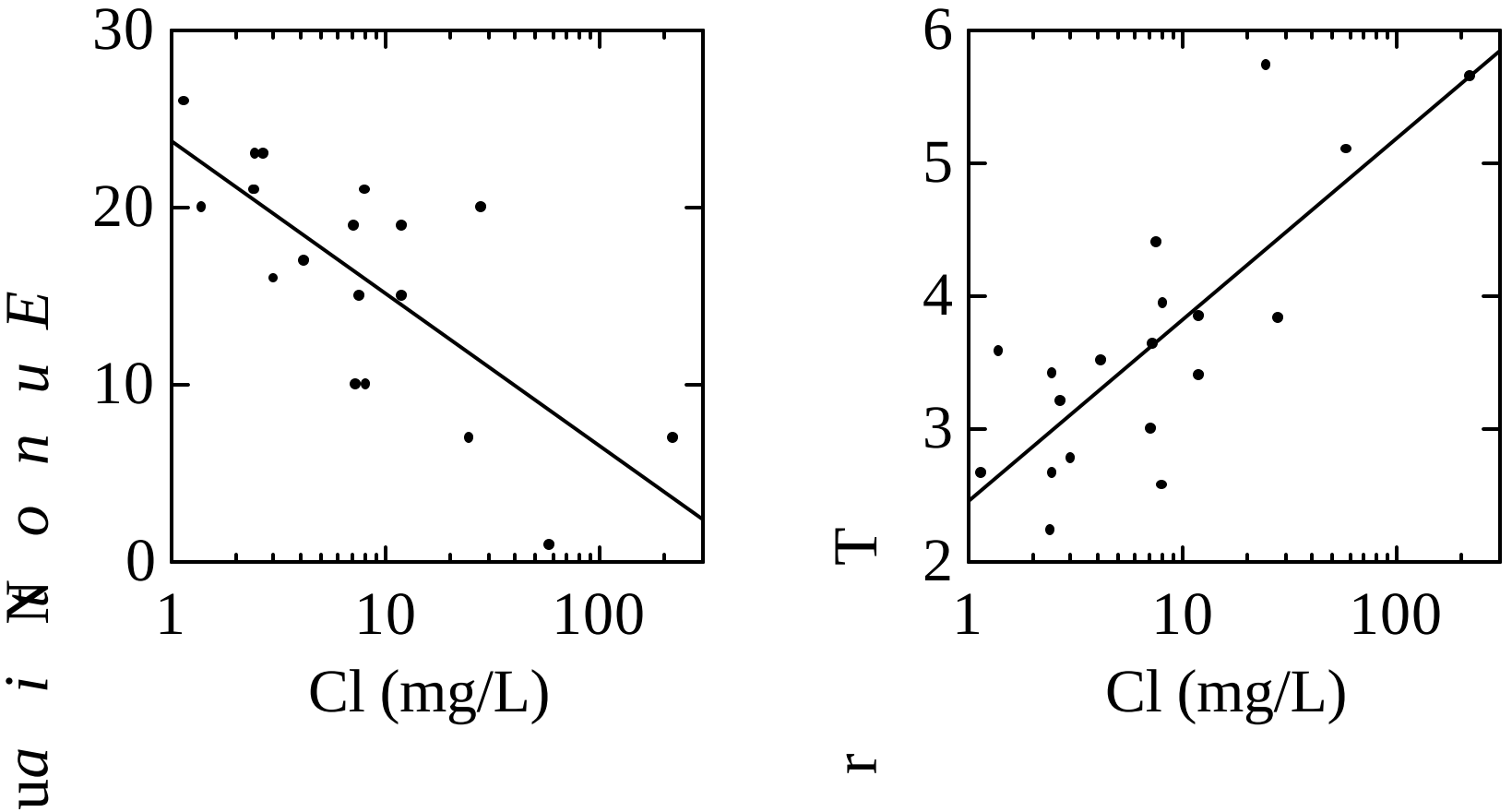
Case Studies

- Algal Indicator Development in Maine Wetlands
- Algal Assessment of Salt Marsh Restoration in North Carolina
- Algal Indicators of Phosphorus Impacts in the Everglades (FLDEP)
- Using Algae to Monitor Phosphorus Conditions in the Everglades (with Curt Richardson and Jennifer Slate)

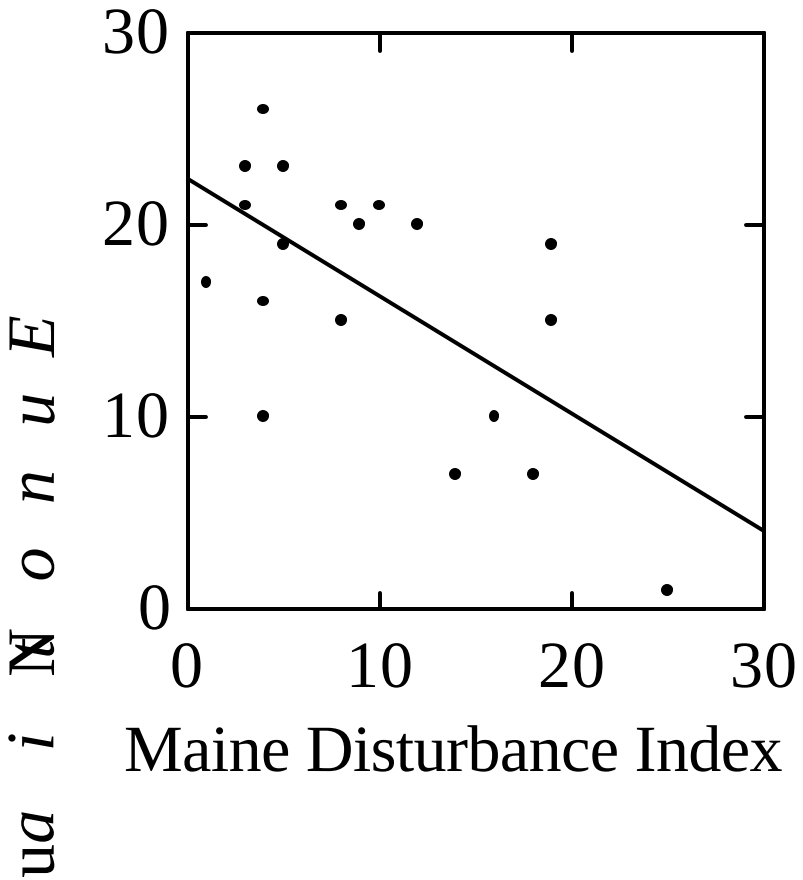
Algal Indicators in Maine Wetlands (with Jeanne Difranco)

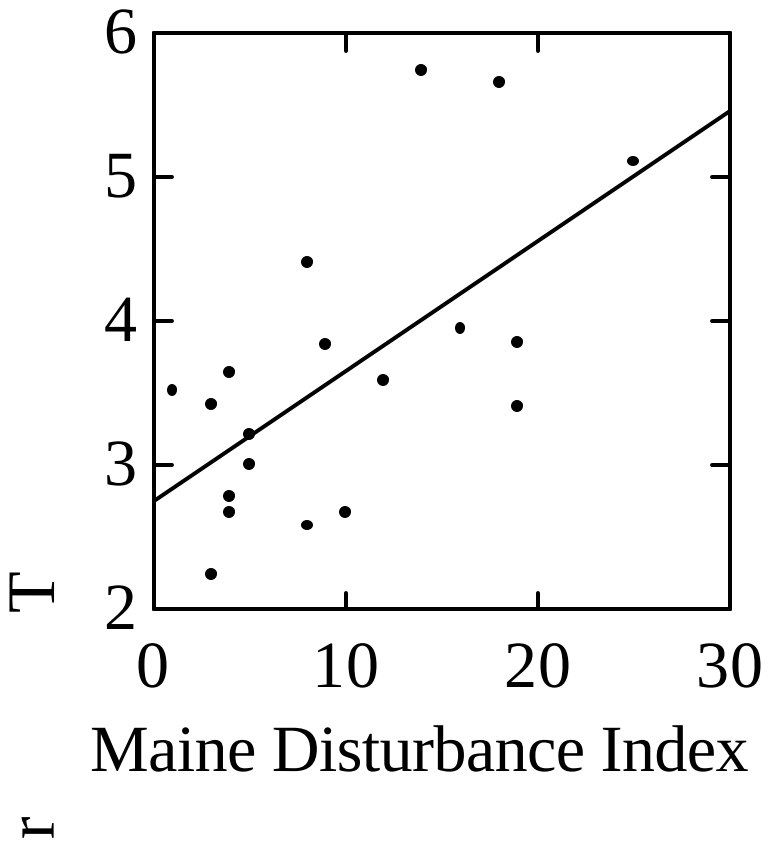
- Twenty wetlands were assessed within the Casco Bay Watershed.
- Land use, water chemistry, and algae were assessed in each
- **A trophic status indicator was calculated with autecological information for diatoms from European streams**
- Results show that many algal attributes change with indicators of human activities
- These algal indicators are reliable over time

Two algal indicators covary in a predictable way with Cl, a common contaminant associated with human disturbance.



Two algal indicators covary in a predictable way with the Maine Disturbance Index (a field characterization of land use and disturbance)

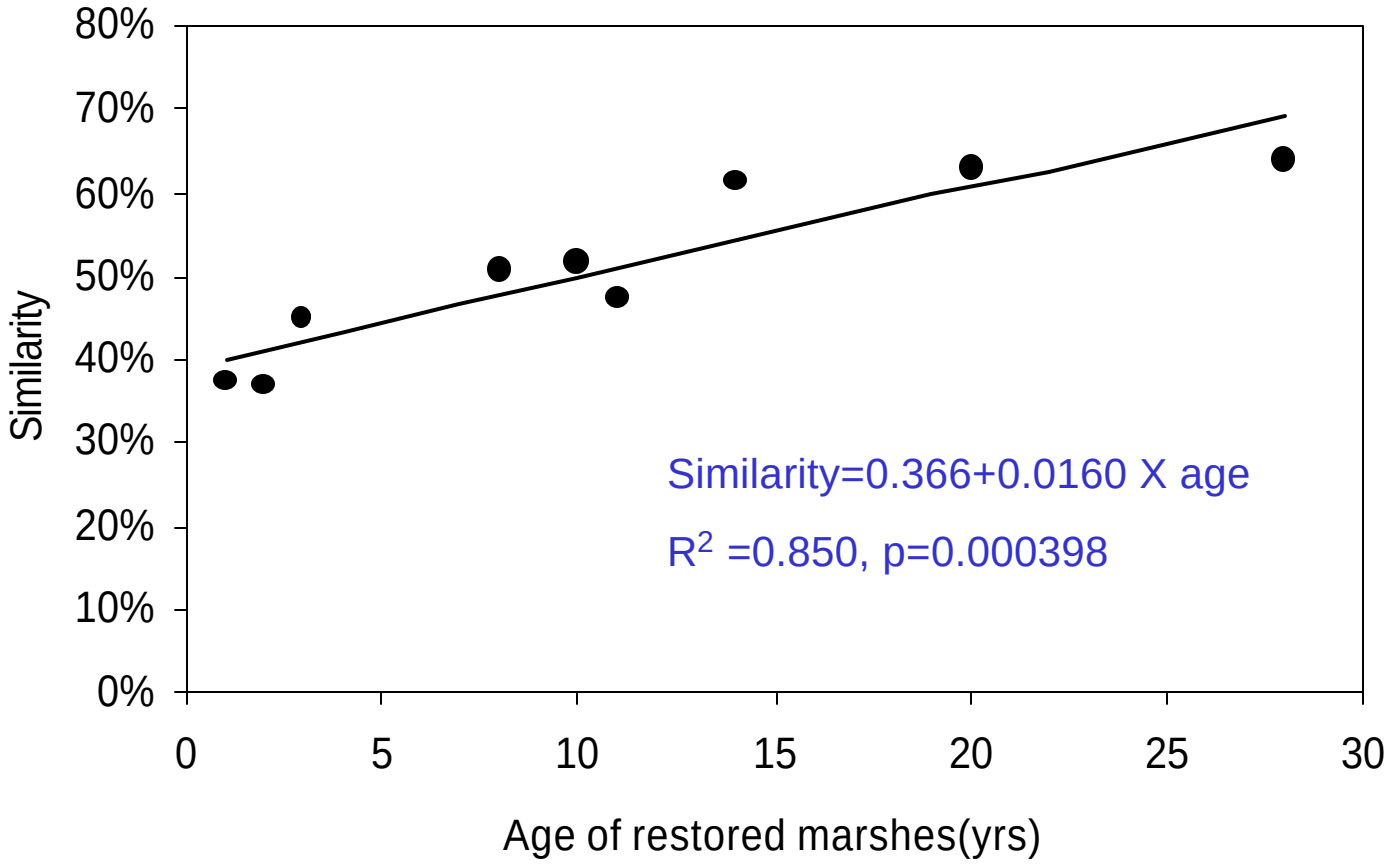




Algal Assessment of Salt Marsh Restoration in North Carolina (with Lei Zheng and Chris Craft)

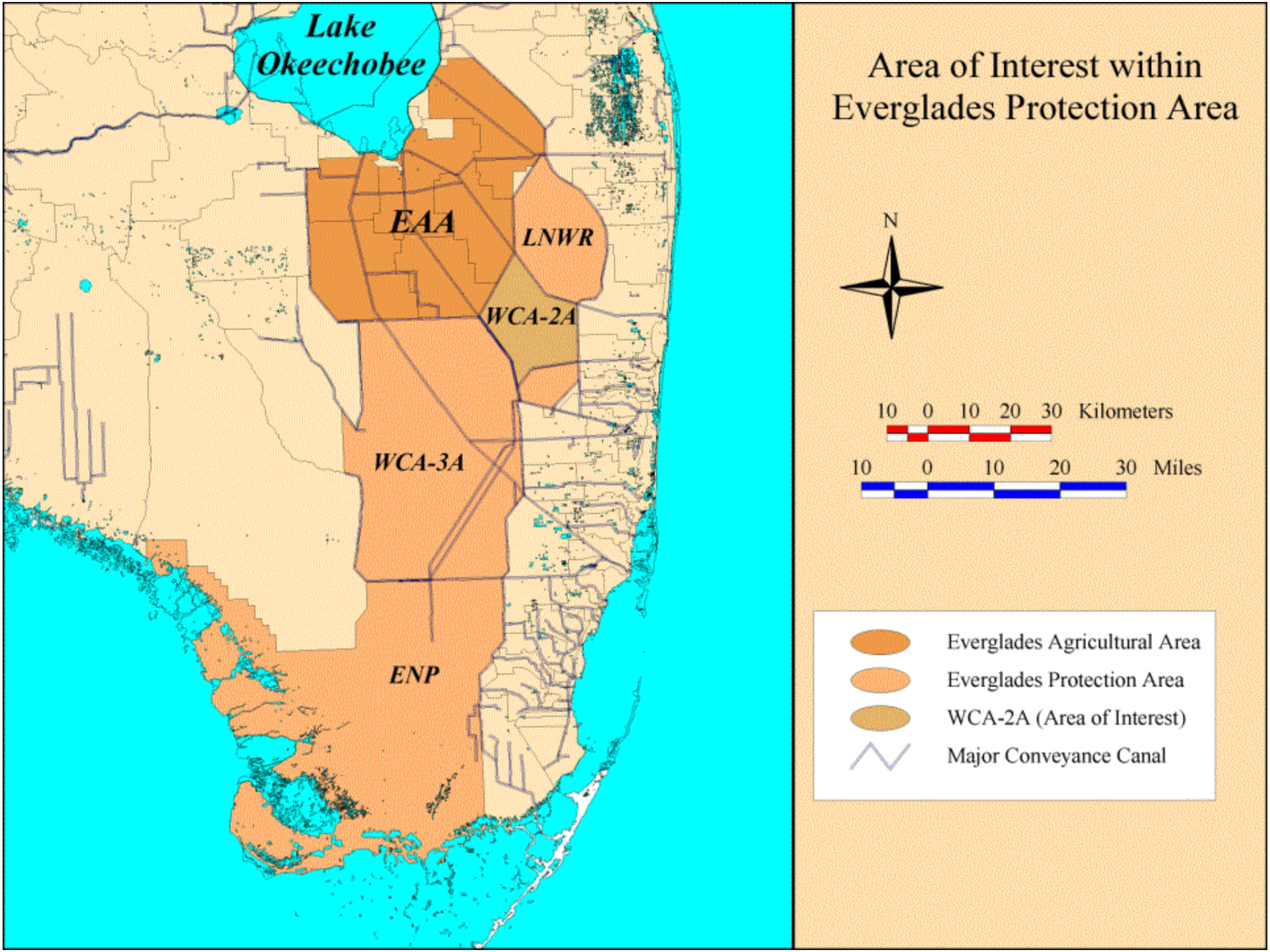
- Algae on plants and sediments were sampled from restored marshes and a reference (>200 years old) marsh nearby each restored marsh.
- Species composition of algae was assessed and compared between the restored marsh and the designated reference marsh.
- Results show that algal assemblages in restored marshes become more similar to reference marshes with increasing age of the restored marsh.

Similarity of diatom species composition between pairs of salt marshes (one restored and one reference marsh) increases with an increase in age of the restored marsh

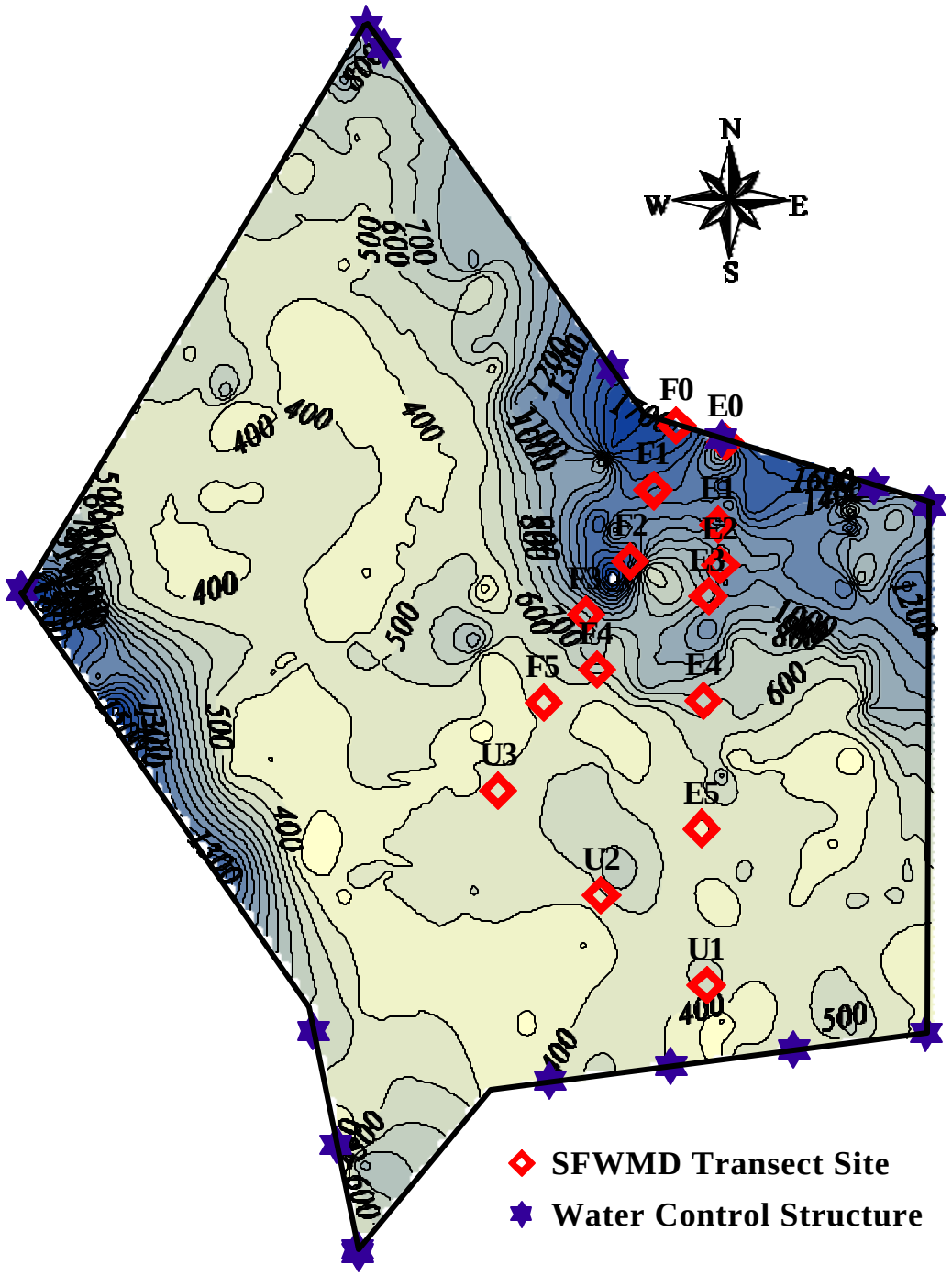


Algal Indicators of Phosphorus Impacts in the Everglades


U3 - Calcareous Mat with *Pomacea*, 2-4-99


Lake Okeechobee
EAA
LNWR
WCA-2A
WCA-3A
ENP
Area of Interest within Everglades Protection Area
N
10 0 10 20 30 Kilometers
10 0 10 20 30 Miles
Everglades Agricultural Area
Everglades Protection Area
WCA-2A (Area of Interest)
Major Conveyance Canal

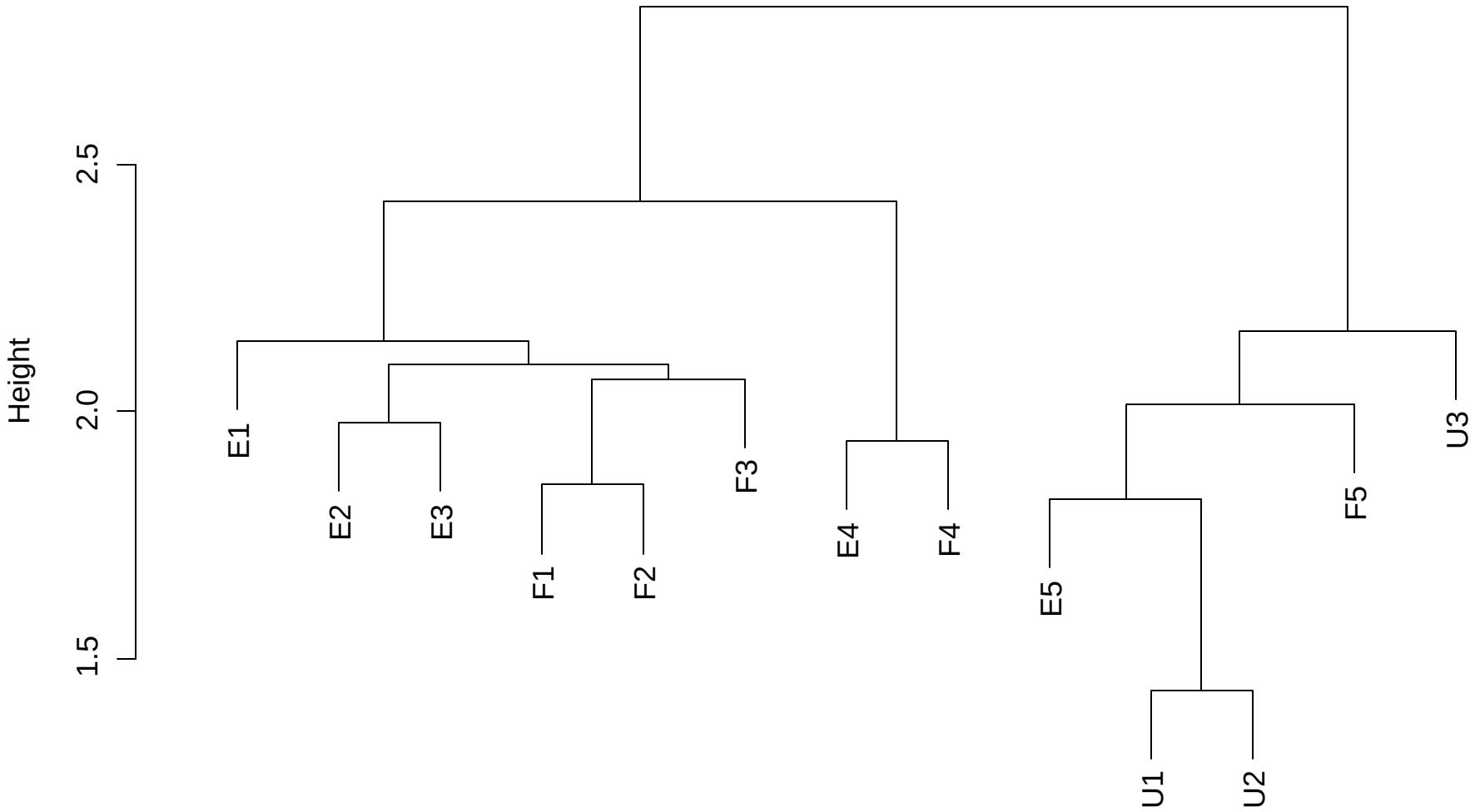
Total Sediment Phosphorus (mg/kg) Contour Map for WCA-2A



Cluster Analysis Based on 452 Periphyton Taxa

7 Sampling Periods (9/7/94, 4/5/95, 11/20/95, 6/6-12/96, 8/22-23/96, 11/18/96, 3/11-12/98)

Using the Agglormerative-Nesting Group Average Method



Sensitive/Tolerant Algal Taxa

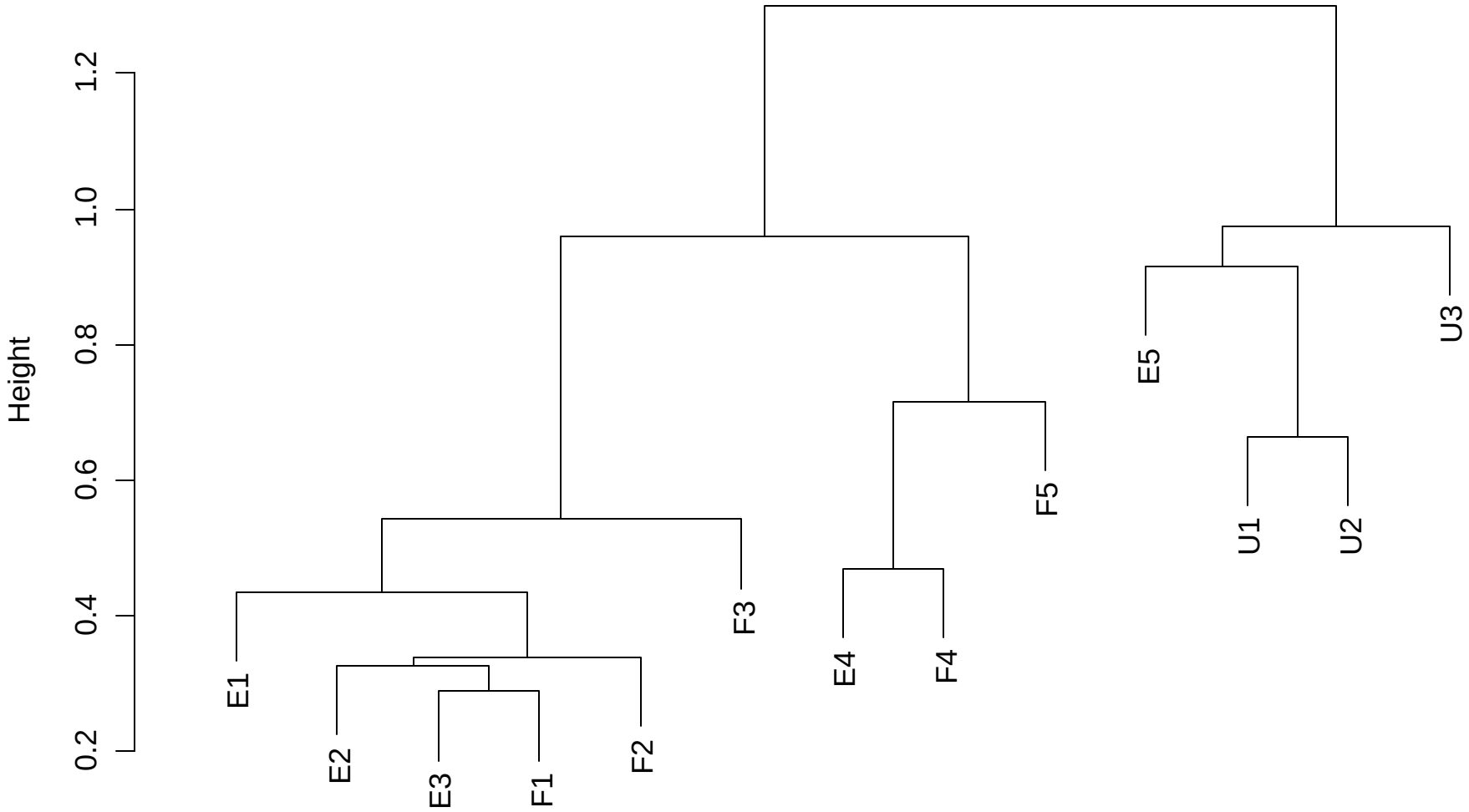
POLLUTION-SENSITIVE*	POLLUTION- TOLERANT*	PHOSPHORUS-SENSITIVE**
Achnanthes exigua	*Gomphonema parvulum*	*Anabaena subcylindrica*
Achnanthes hustedtii	*Navicula minima*	*Anomoeneis vitrea*
Achnanthes linearis	*Navicula viridula*	*Cymbella lunata*
Achnanthes microcephala	*Nitzschia amphibia*	*Cymbella minuta*
Achnanthes minutissima	*Nitzschia frustulum*	*Mastogloia smithii*
Amphora ovalis	*Nitzschia palea*	*Synechococcus cedrorum*
Anomoeneis serians	*Oscillatoria*	
Anomoeneis vitrea	*Rhopalodia gibba*	
Cymbella microcephala	*Scenedesmus*	
Cymbella minuta	*Anabaena*	
Navicula radiosa	*Cosmarium*	
Synedra rumpens	*Lyngbya*	
Cymbella lunata		
Mastogloia smithii		

***Indicated by two or more of the following sources: Lowe (1994), Whitmore (1989), Bahls (1993), Metzmeier (1995), Palmer (1969), Lange-Bertalot (1979), Adamus (1990), Romie (1990), Duke Wetland Center 1996-1997 Biennnial Report (1997), McCormick and Odell (1996). **Determined based on results from SFWMD P-dosing mesocosm studies.**

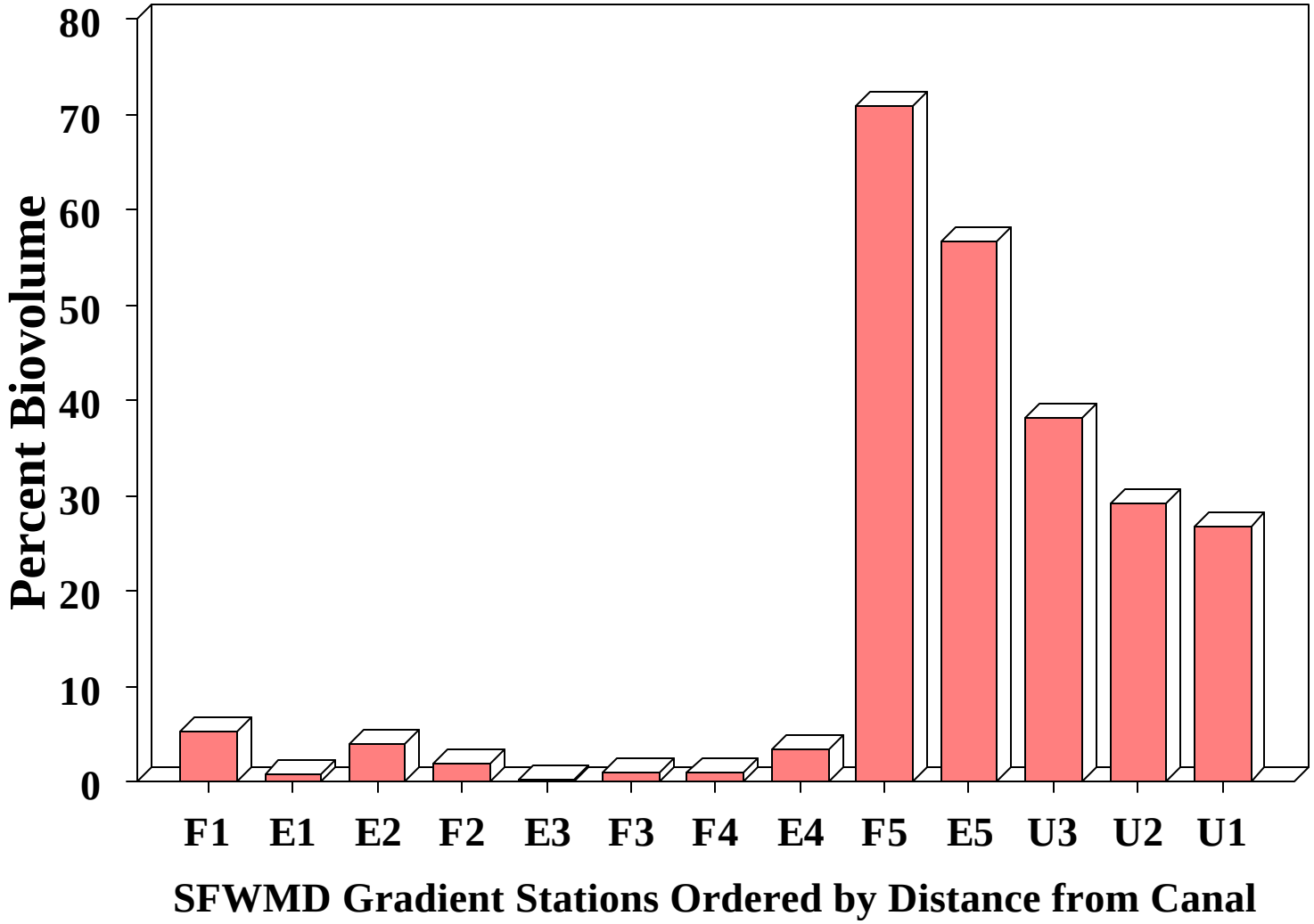
Cluster Analysis Based on Phosphorus-Sensitive (Mesocosm Based) Periphyton Taxa

7 Sampling Periods (9/7/94, 4/5/95, 11/20/95, 6/6-12/96, 8/22-23/96, 11/18/96, 3/11-12/98)

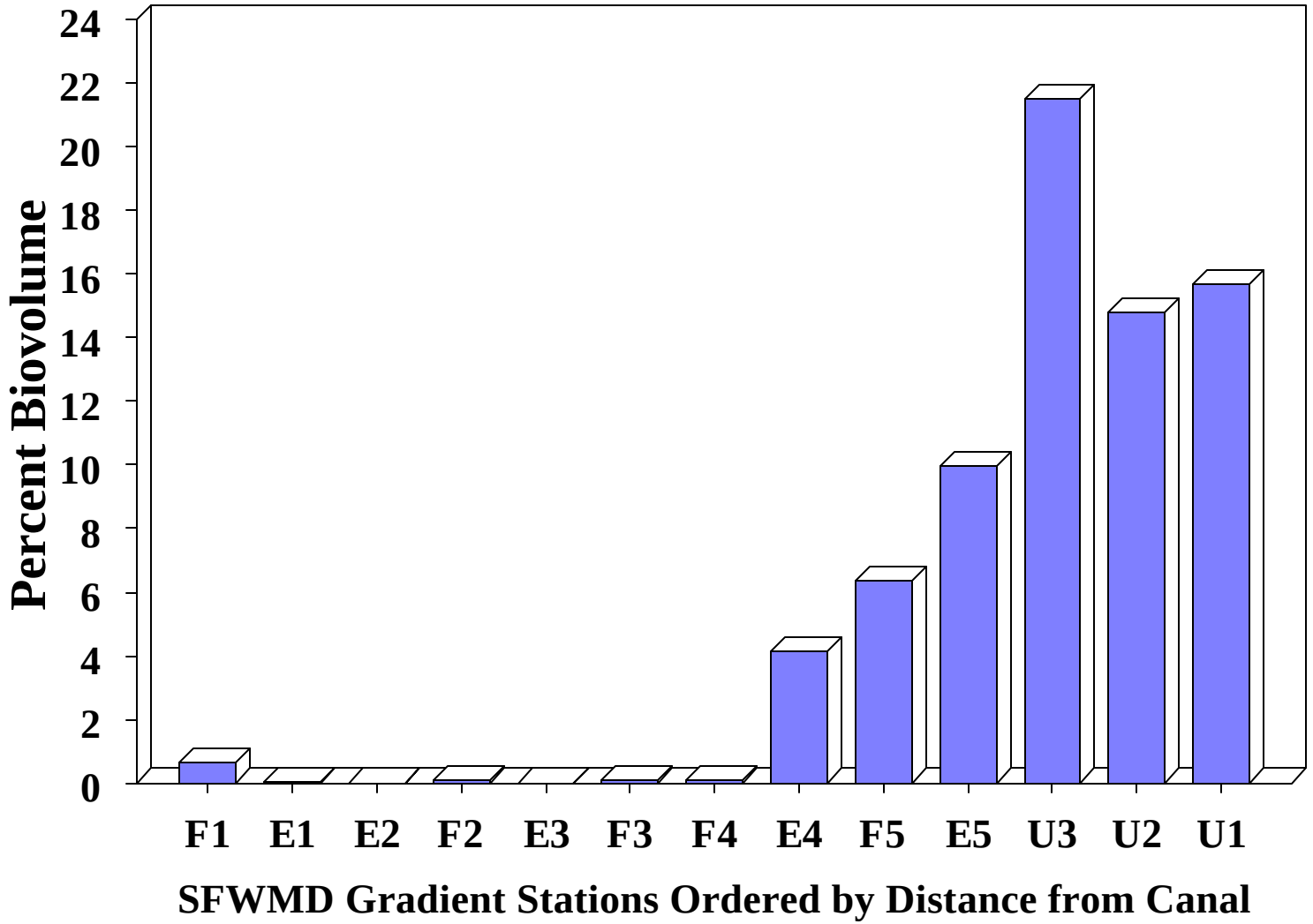
Using the Agglormerative-Nesting Group Average Method



Percent Calcareous Periphyton (*Scytonema, Schizothrix*) from Natural Substrate Samples Collected by the SFWMD on 12-5-95



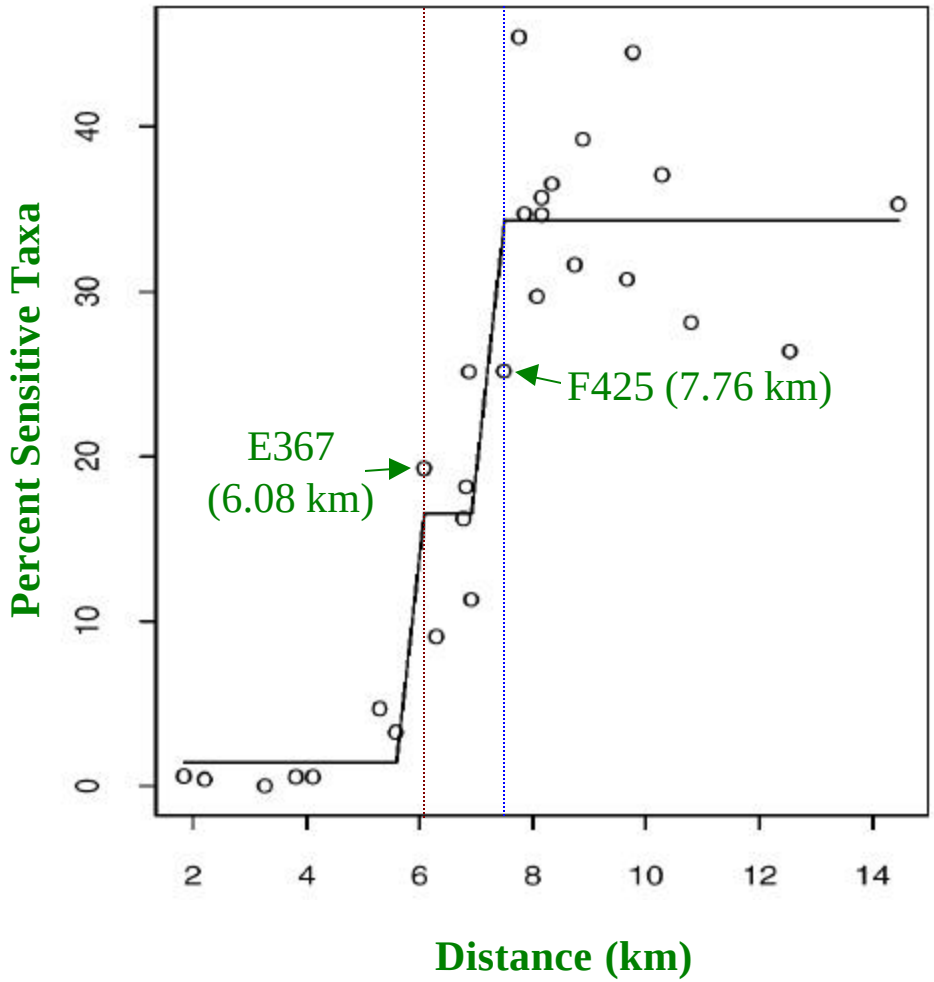
Percent Sensitive Diatoms from Natural Substrate Samples Collected by the SFWMD on 12-5-95



Results of Change Point Analyses Performed on Median Total Percentage of Pollution-Sensitive (Literature Determined) Periphyton Taxa.

SFWMD Transects

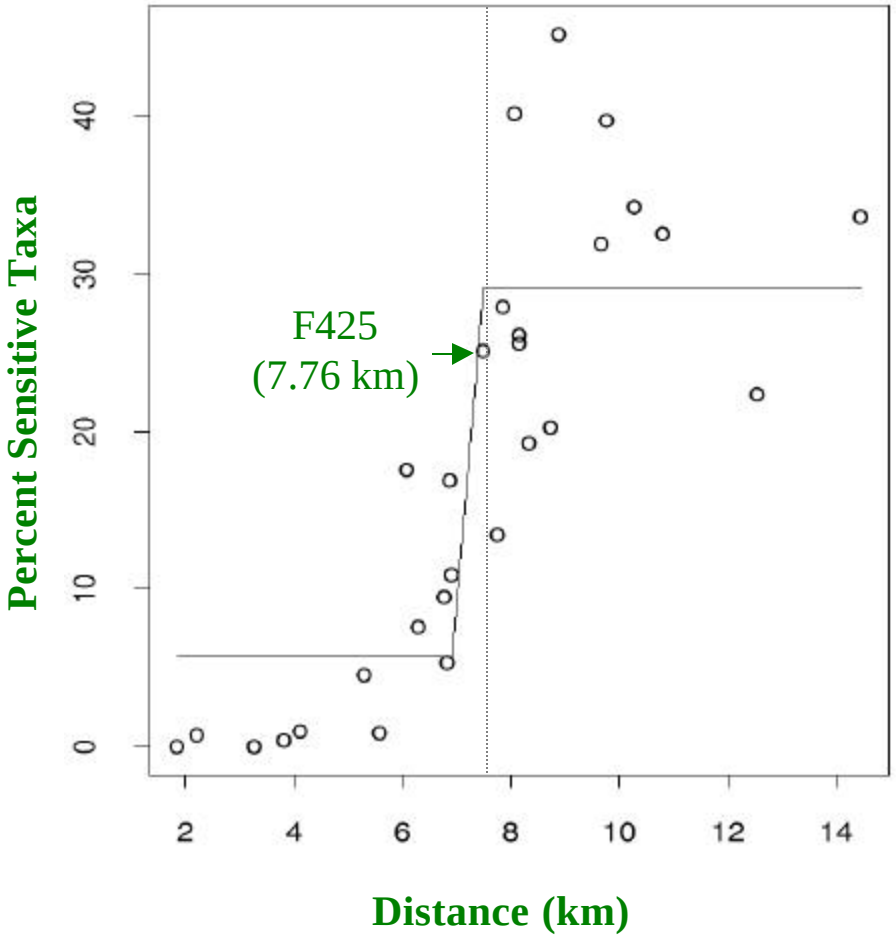
7 Sampling Periods (9/7/94, 4/5/95, 11/20/95, 6/6-12/96, 8/22-23/96, 11/18/96, and 3/11-12/98).



Results of Change Point Analyses Performed on Median Total Percentage of Phosphorus-Sensitive (Mesocosm Determined) Periphyton Taxa

SFWMD Transects

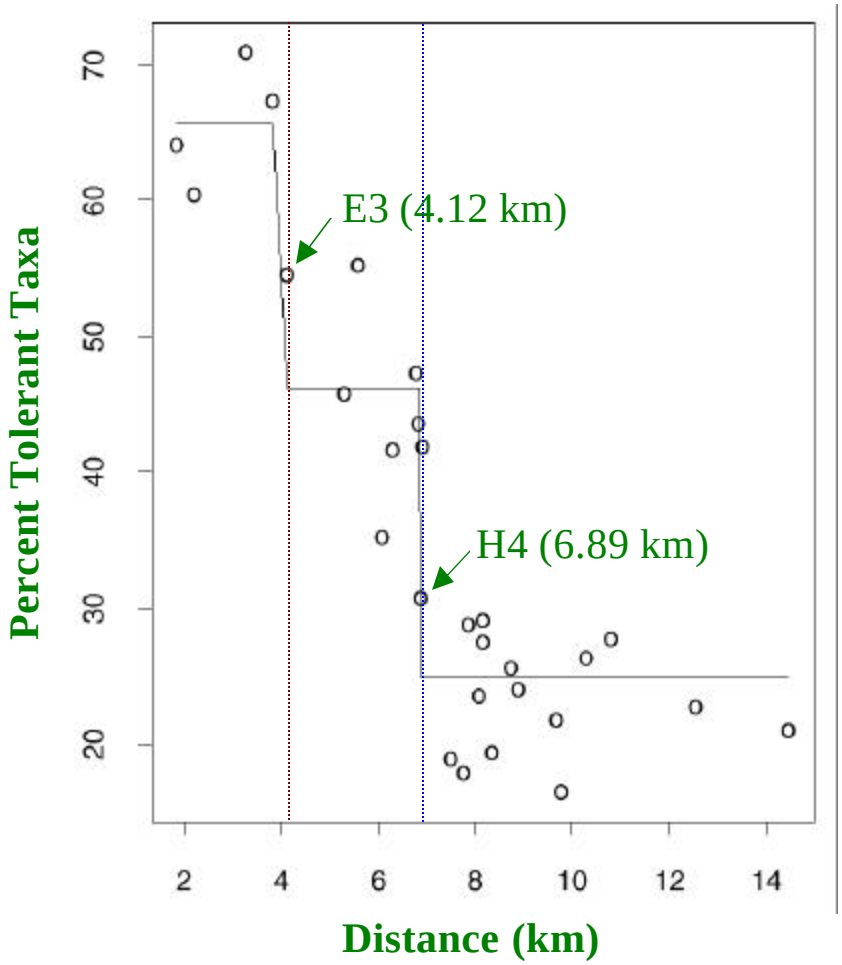
7 Sampling Periods (9/7/94, 4/5/95, 11/20/95, 6/6-12/96, 8/22-23/96, 11/18/96, and 3/11-12/98)



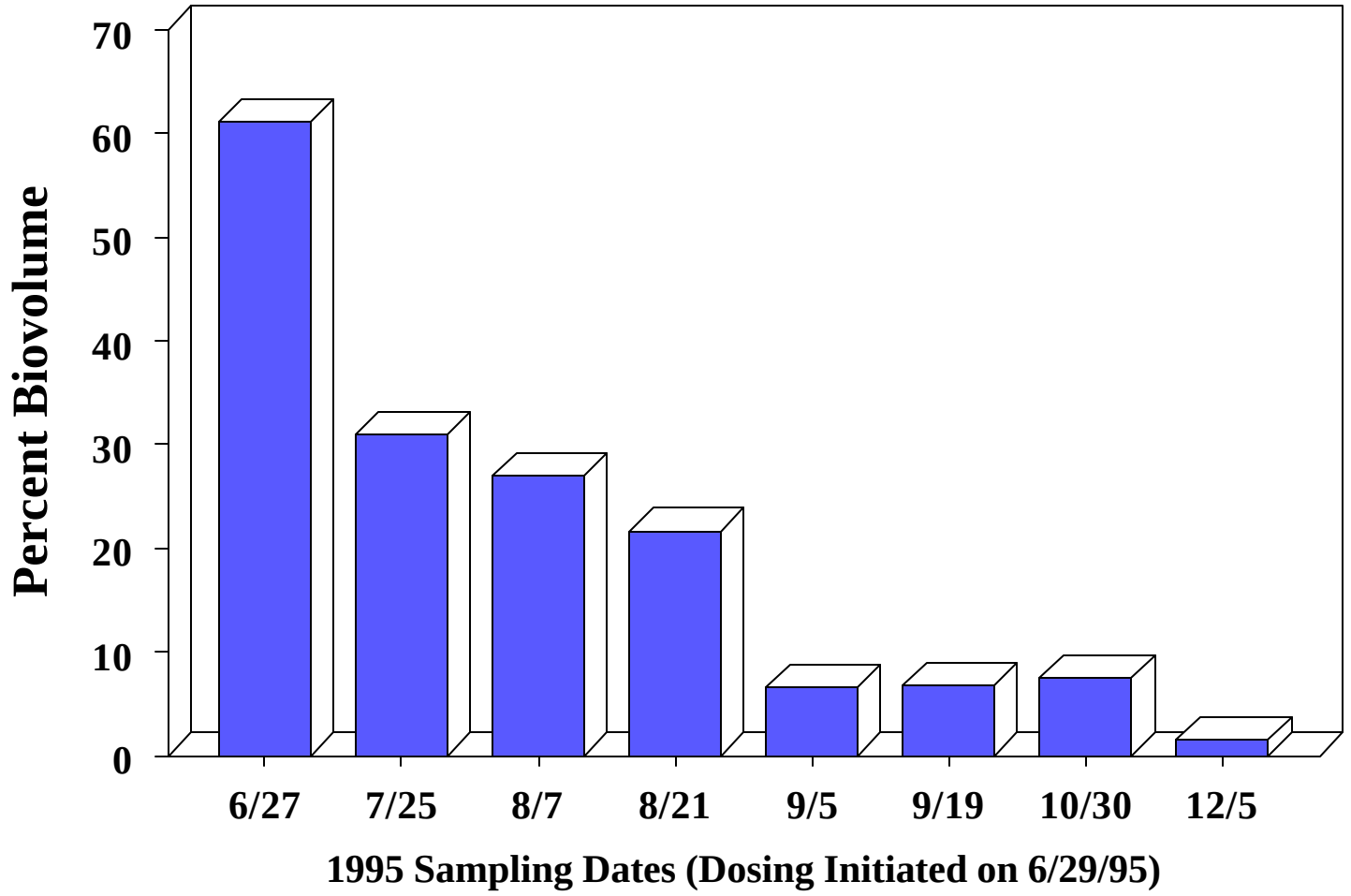
Results of Change Point Analyses Performed on Median Total Percentage of Pollution-Tolerant (Literature Determined) Periphyton Taxa.

SFWMD Transects

7 Sampling Periods (9/7/94, 4/5/95, 11/20/95, 6/6-12/96, 8/22-23/96, 11/18/96, and 3/11-12/98)



Percent Biovolume Comprised of Calcareous Periphyton in SFWMD Mesocosms Dosed with 12.8 g $P \cdot m^{-2} \cdot y^{-1}$ from June 27, 1995 (pre-dosing) through December 5, 1995



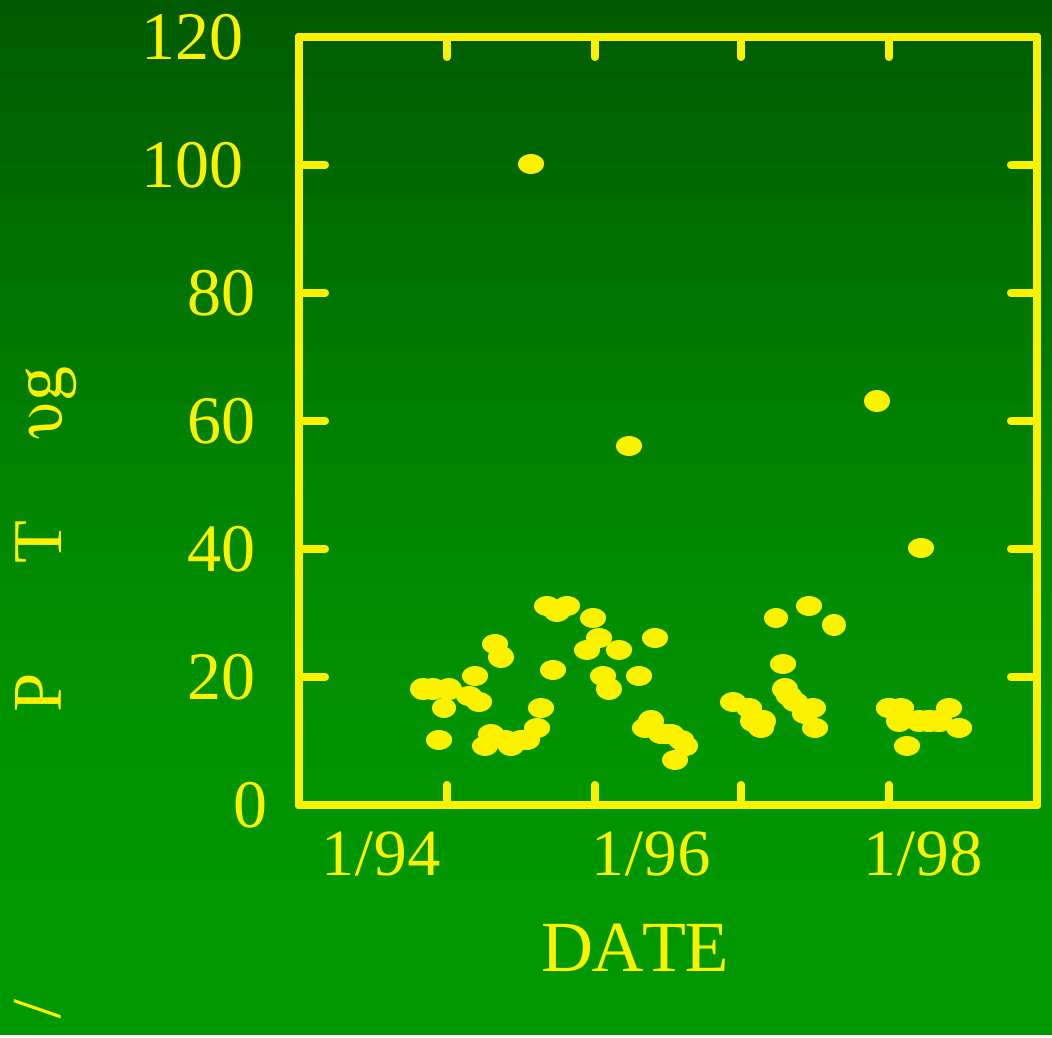
Using Algae to Monitor Phosphorus Condition in the Everglades (with Curt Richardson and Jennifer Slate)

- Algae should provide a temporally integrated indicator of environmental conditions.
- Algae and water chemistry were sampled and assayed.
- Weighted average indicators of total phosphorus were developed based on relative abundance of algal species in samples and P optima of those species.

Results Show:

DIATOM INDICATORS OF ENVIRONMENTAL CONDITIONS CAN BE MORE PRECISE THAN ONE-TIME SAMPLING AND ASSESSMENTS OF WATER CHEMISTRY!

Measured Total Phosphorus Varies Greatly over Time (e.g. a Site in Everglades)



Weighted Average Metrics Are Relatively Easy to Calculate

Infer Environmental Conditions with Species Relative Abundances and Environmental Optima

$$EC = S\, n_i Q_i$$

Calculating Spp Optima and Inferred Conditions

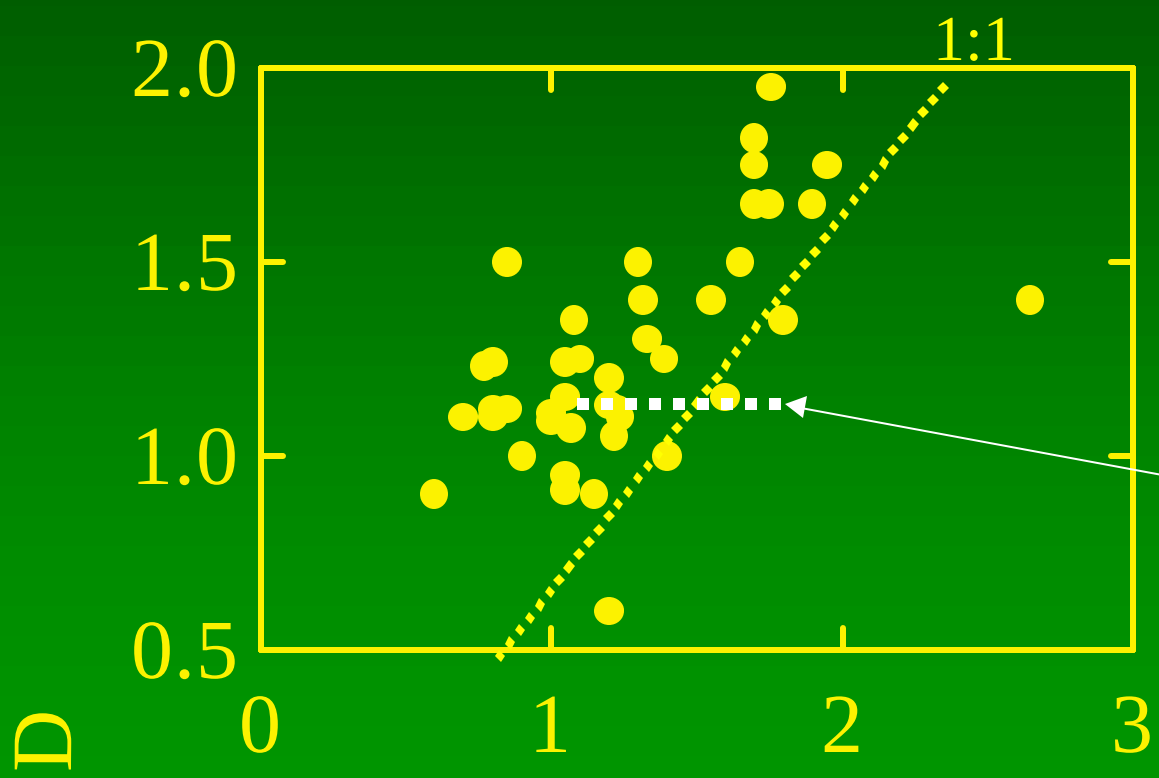
- Sp Optimum

Taxon	Site #	Rel Abund	TP Conc	RA*Conc
Navicula veneta	1	0.50	50	25.00
Navicula veneta	2	0.01	5	0.05
Navicula veneta	3	0.01	5	0.05
…….	…..	…..	…..	…..
Navicula veneta	n	0.05	20	1.00
Sums		0.57		26.10
Optimum				45.79

- Inferred TP

Taxa	Site #	Rel Abund	TP Opt	RA*Opt
Navicula veneta	1	0.50	45	22.50
Navicula minima	1	0.24	51	12.24
Navicula capitat	1	0.24	59	14.16
…….	…..	…..	…..	…..
Cymbella tumida	1	0.02	142	2.84
Sums		1.00		51.74
Inferred TP Conc				51.74

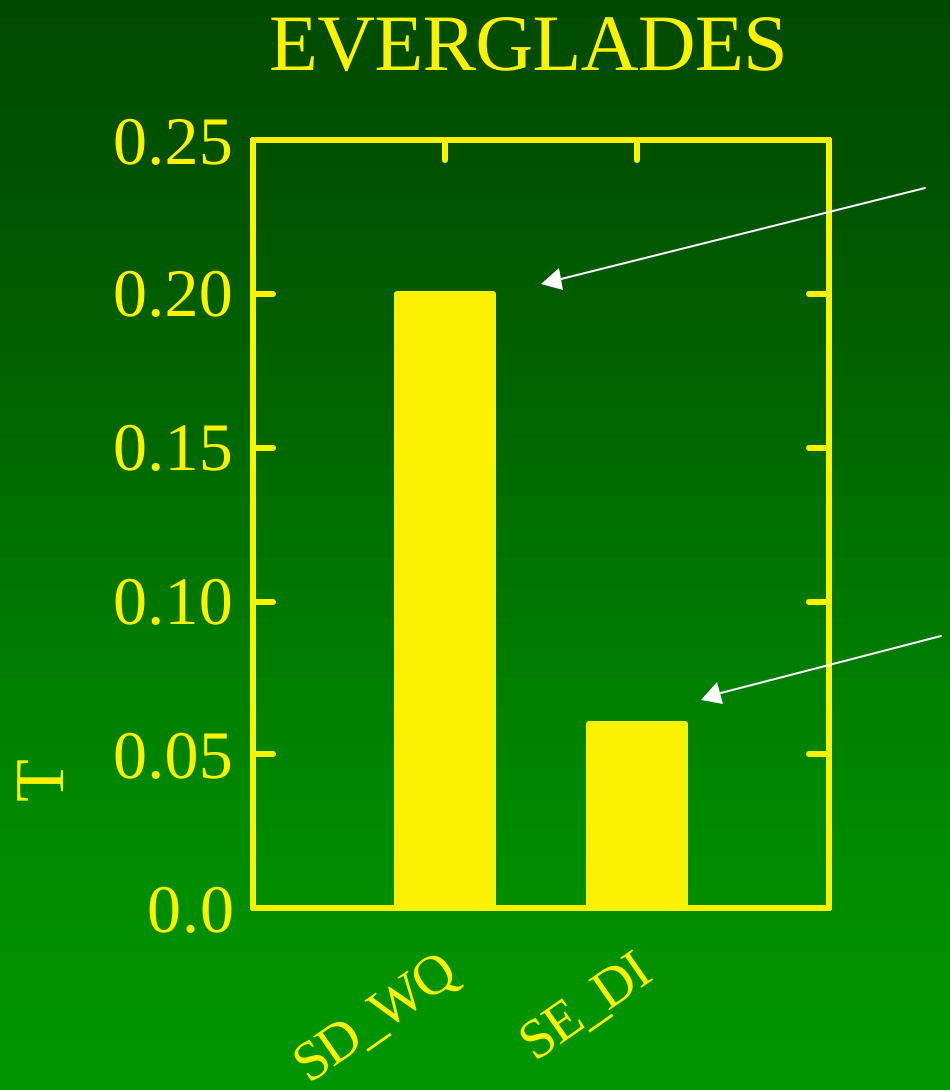
Diatom Inferred TP is very Similar to Measured TP



r^2=0.63

RMSE=0.23

RMSE is a measure of the variability in P inferred based on diatom model.



Standard deviation of measured TP is variability associated with single observations.

Standard error of diatom-inferred TP is variability associated with inferring TP based on indicator from one algal sample.

Review

- Algal sampling is relatively easy and identifying algae, particularly diatoms, is not hard.
- Algal indicators have been developed for wetlands and can be borrowed from streams (even European streams).
- Algae provide sensitive and precise responses to environmental change.